Atmospheric, Cloud, and Surface Parameters Retrieved from Satellite Ultra-spectral Infrared Sounder Measurements

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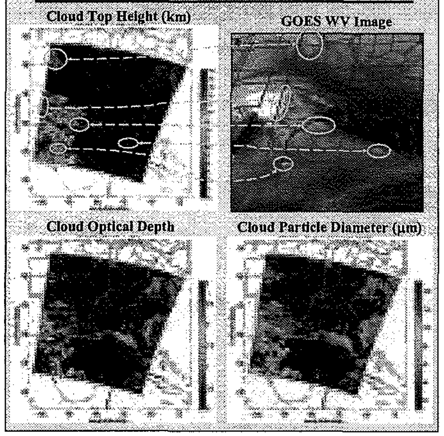
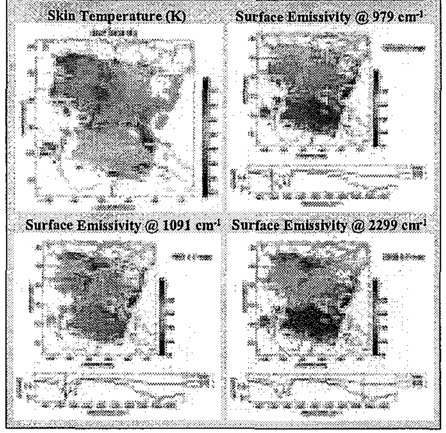
ABSTRACT

An advanced retrieval algorithm with a fast radiative transfer model, including cloud effects, is used for atmospheric profile and cloud parameter retrieval. This physical inversion scheme has been developed, dealing with cloudy as well as cloud-free radiance observed with ultraspectral infrared sounders, to simultaneously retrieve surface, atmospheric thermodynamic, and cloud microphysical parameters. A fast radiative transfer model, which applies to the clouded atmosphere, is used for atmospheric profile and cloud parameter retrieval. A one-dimensional (1-d) variational multi-variable inversion solution is used to improve an iterative background state defined by an eigenvector-regression-retrieval. The solution is iterated in order to account for non-linearity in the 1-d variational solution. This retrieval algorithm is applied to the MetOp-A satellite Infrared Atmospheric Sounding Interferometer (IASI) launched on 19th October 2006. IASI possesses an ultra-spectral resolution of 0.25 cm^{-1} and a spectral coverage from 645 to 2760 cm^{-1}. Preliminary retrievals of atmospheric soundings, surface properties, and cloud optical/microphysical properties with the IASI measurements are obtained and presented.

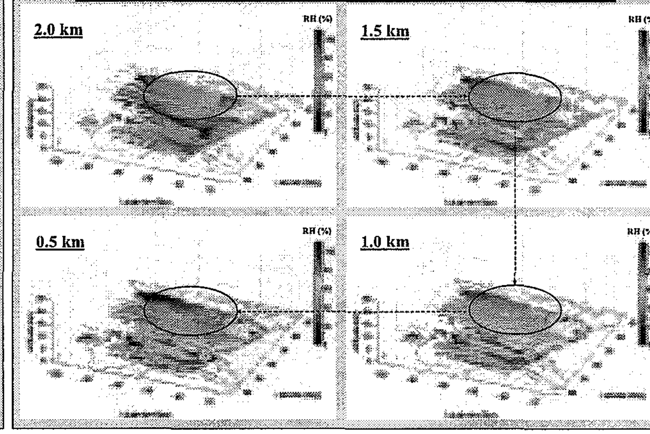
CLOUD PROPERTIES RETRIEVED



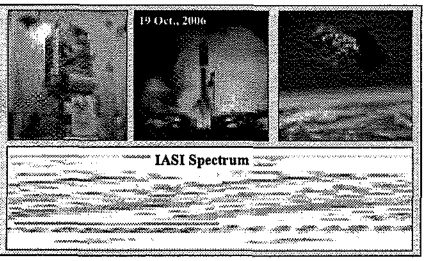
SURFACE PROPERTIES RETRIEVED



TBL MOISTURE VARIATION CAPTURED BY IASI



Infrared Atmospheric Sounding Interferometer (IASI) instrument (by CNES / EUMETSAT) on MetOp-A Satellite launched on 19 October 2006



RETRIEVAL METHODOLOGY

(Single FOV under all-sky conditions)

PART A: REGRESSION RETRIEVAL

Diagnose 0-2 cloud layers from radiosonde relative humidity profile:

A single cloud layer is inserted into the input radiosonde profile. Approximate lower level cloud using opaque cloud representation.

Use parameterization of balloon and aircraft cloud microphysical data base to specify cloud effective particle diameter and cloud optical depth (Heymsfield et al., 2003):

Different cloud microphysical properties are simulated for same radiosonde using random number generator to specify visible cloud optical depth within a reasonable range. Different habitats can be specified (Hexagonal columns assumed here).

Use LBLRTM/DISORT "lookup table" to specify cloud radiative properties (Yang et al., 2001):

Spectral transmittance and reflectance for ice and liquid clouds interpolated from multi-dimensional look-up table based on DISORT multiple scattering calculations.

Compute EOFs and Regressions from cloudy radiance data base:

Regress cloud properties, surface & atmospheric profile parameters against radiance EOFs.

PART B: 1-D VAR PHYSICAL RETRIEVAL

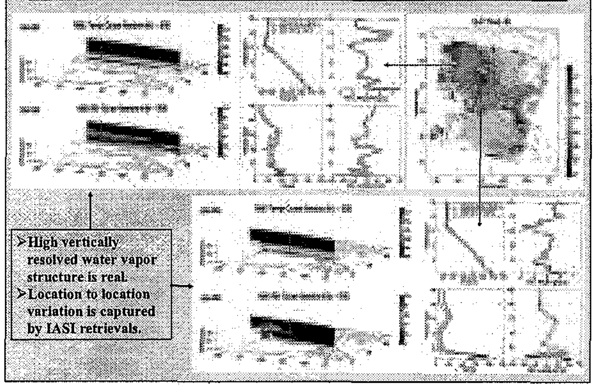
A one dimensional (1-d) variational solution, also known as the regularization algorithm or the minimum information method, is chosen for physical retrieval methodology which uses the regression solution as the initial guess.

Cloud microphysical parameters, namely effective particle diameter and visible optical thickness, are further refined with the radiances observed within the 10.4 μm to 12.5 μm window region.

Heymsfield, A. J., S. Matrosov, and B. Baum (2003), Ice water path-optical depth relationships for cirrus and deep stratiform ice cloud layers, *J. of Appl. Meteorol.*, 42, 1369–1390.

Yang, P., B. C. Gao, B. A. Baum, Y. Hu, W. Wiscombe, S.-C. Tsay, D. M. Winker, S. L. Nasiri (2001), Radiative Properties of cirrus clouds in the infrared (8-13 μm) spectral region, *J. Quant. Spectros. Radiat. Transfer*, 70, 473-504.

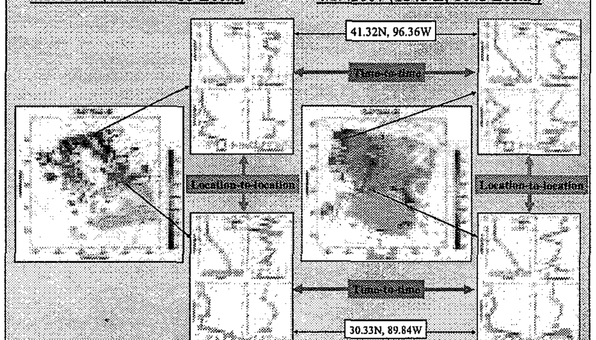
ATMOSPHERIC VARIATION CAPTURED BY IASI



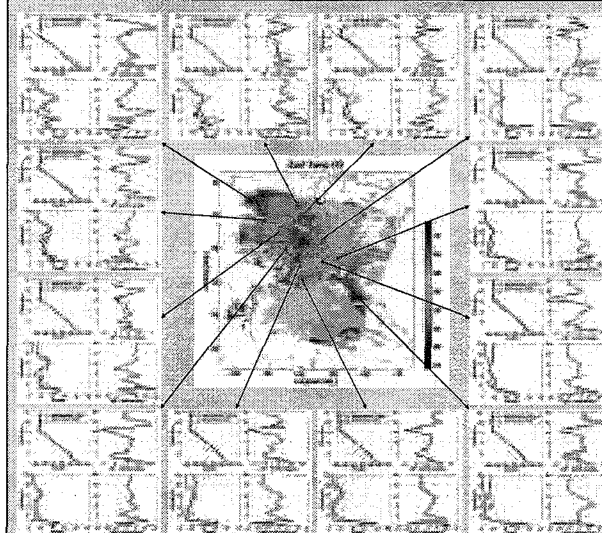
TIME-TO-TIME & LOCATION-TO-LOCATION

4.19.2007 (0333Z, 2233 Local)

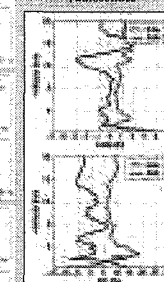
4.29.2007 (1545 Z; 1045 Local)



IASI (1545 UTC) VS. RAOBS (1200 UTC)



Radiosonde and IASI retrieval comparison and statistical profiles over 13 radiosondes



IASI temperature and moisture profile accuracy is within 1 K per 1 km and 10% per 2 km, respectively (preliminary)

Note:
1200 UTC = 0700 Local
1545 UTC = 1045 Local

SUMMARY

A State-of-the-art retrieval algorithm dealing with all-weather conditions, developed with NAST-I, has been applied to satellite instruments retrieving cloud/surface and atmospheric conditions with a "higher" spatial resolution (single field-of-view). First of many case studies of IASI indicate that atmospheric conditions were captured coherently. High quality retrievals have been achieved from algorithm application to space-based IASI data. Surface, cloud, and atmospheric structure and variation are well captured by IASI measurements and/or retrievals. High vertically resolved atmospheric structure is revealed with IASI retrievals. Preliminary evaluation indicates that IASI temperature and moisture profile accuracy is within 1 K per 1 km and 10% per 2 km, respectively. Additional validation analyses are needed to provide more-definitive conclusions. This work has laid a foundation for some critical studies such as retrieval algorithm refinery, satellite remote instrument validation and inter-comparison, and risk reduction study for future instrument development.